63-3-4

A SURVEY OF GEOMAGNETIC MICROPULSATION RESEARCH CONDUCTED IN CONNECTION WITH THE CO-OPERATIVE GEOMAGNETIC MICROPULSATION MEASUREMENT PROGRAM

Report No. 130

15 May 1963

Compiled by

H. W. Smith

Electrical Engineering Research Laboratory

The University of Texas

under

Contract Nonr 375(14)

NR 371-032

OFFICE OF NAVAL RESEARCH

Washington, D. C.

404387

The research in this document has been made possible through the support and sponsorship extended by the Office of Naval Research under Contract Nonr 375(14). It is published for technical information only and does not necessarily represent recommendations or conclusions of the sponsoring agency.

A SURVEY OF GEOMAGNETIC MICROPULSATION RESEARCH CONDUCTED IN CONNECTION WITH THE CO-OPERATIVE GEOMAGNETIC MICROPULSATION MEASUREMENT PROGRAM

Report No. 130

15 May 1963

Compiled by

H. W. Smith

Electrical Engineering Research Laboratory

The University of Texas

under

Contract Nonr 375(14)
NR 371-032

OFFICE OF NAVAL RESEARCH

Washington, D. C.

TABLE OF CONTENTS

ABSTRACT

At a conference on geomagnetic micropulsations held at the University of California on August 12-14, 1962 a committee was formed from representatives of the several research groups in attendance to conduct a survey to determine the desirability of a co-operative measurement program. The favorable response from this survey resulted in the formation of the Co-Operative Geomagnetic Micropulsation Measurement Program. This report contains a condensed summary of a survey form mailed to all research groups in the United States and Canada known to have an interest in geomagnetic micropulsations.

I. INTRODUCTION

In the years following the IGY there has been a very rapid increase in both interest and research activity in geomagnetic micropulsations and related phenomena. Although no concise definition of the term micropulsa- is generally recognized, most investigators will agree that the frequency range from about 0.001 to 5.0 cps includes most of the signals of interest. In this frequency range there is, thus, some overlap between the micropulsation measurements and the normal and rapid-run magnetograms that have been well standardized and widely recorded by geomagnetic observatories for many years.

Within the past few years a number of investigators have voiced a growing need for a more complete geographical coverage of micropulsation and earth current measurements, as well as a desire for suitable standards for equipment, bandwidths, and calibration procedures. For these reasons a number of research activities represented at a conference on Geomagnetic Micropulsations held at the University of California on August 12-14, 1962 decided to take positive steps toward a co-operative program designed to help satisfy some of these needs.

As a first step, a co-ordinating committee for what has become known as the Co-operative Geomagnetic Micropulsation Measurement Program (CGMMP) was selected. This committee was initially charged with the task of conducting a survey to determine the interest and willingness of research

activities to participate in such a program. If the survey showed an insufficient interest on the part of the research groups, the whole program would be abandoned without further effort. It was decided that a favorable response would warrant the establishment by this committee of recording schedules, the gathering and distribution of selected data, the study of equipment and standards, and a variety of other activities associated with the program. Members of this co-ordinating committee are as follows:

H. W. Smith - The University of Texas - Chairman
A. K. Harris - S.R.D.L. - Fort Monmouth
J. R. Heirtzler - Lamont Geological Observatory
V. P. Hessler - Geophysical Institute - University of Alaska
S. H. Ward - University of California

It is the purpose of this brief report to summarize the results of a survey form mailed to all research groups in the United States and Canada known to have an interest in geomagnetic micropulsation phenomena.

II. SURVEY RETURNS

A copy of the original survey form is shown in Appendix A. In addition to questions relating to equipment, test sites, timing, etc., entries were requested regarding special interest, data processing facilities, willingness to participate in a joint measurement program, and comments and suggestions.

From these original returns a condensed form, mostly relating to equipment and measurements, was compiled. These condensed forms are

shown in Appendix B. A total of 30 research groups listing approximately 60 fixed or mobile sites are included in this summary. In addition a number of investigators involved in theoretical studies or in related fields expressed a desire to receive copies of data and results obtained from the program.

III. SURVEY RESULTS

A study of the original returns and accompanying letters, publications, and reports provides the basis for the following observations and conclusions:

1. Perhaps the most significant result of the survey is the fact that an overwhelming majority of the replies were in favor of the program and promised co-operation in varying degrees ranging from 100% to occasional participation if it did not interfere with other commitments. The most frequent reply was to the effect that co-operation would be to the fullest extent that facilities and prior commitments would permit.

2. The survey revealed, as expected, a wide diversity in equipment and recording techniques. There is no question but that this diversity constitutes a major difficulty in the exchange of data. A subcommittee is currently studying this problem, but since so much of the equipment is already in existence, attempts to standardize in the early stages of the program will have to be on a minor scale. This problem is really international in scope and is currently under study by Committee No. 10 of IAGA. It was mentioned more than anything else in the comments and suggestions entry on the survey.

3. Partly as a consequence of the equipment and operating diversity mentioned in item 2, the original survey form was not entirely appropriate as is often the case. Thus, the amount of detail in the descriptions of equipment and recording techniques varied from meager to most elaborate, requiring numerous footnotes and explanations. Some caution is, therefore, appropriate in using the condensed forms as they were difficult to compile, and there are no doubt important omissions and inaccuracies. Questions on specific details should be directed to the individual investigators.

4. No claim is made that this survey represents all of the research currently being conducted in this area. On the contrary, the committee is well aware of highly significant programs operated by other groups and individuals. In general, these programs have specific experiments in progress and the data are not generally available to a group as large as the CGMMP. Notable in this regard are the networks of stations operated by Benioff, Campbell, Maple and others.

5. It should not be expected that every research group will participate in every simultaneous recording period. Hopefully, a reasonable percentage will be in operation on any given test.

6. The geographic distribution of stations is evident in the condensed forms, but may be summarized as follows: The largest concentration of stations is in the U.S.-northeast-Canadian-southeast, or along the 70th meridian. There is a secondary grouping along the west coast of North America. Some coverage in the Pacific, Puerto Rico, New Zealand

and Japan is anticipated. Certain European stations, particularly the French who also operate in South Africa, have expressed a willingness to co-operate on specific occasions. Notable gaps exist in the lower latitudes and in the mid-continent area. As mentioned in item 5, however, the actual coverage may vary considerably. In any event the network is potentially larger than any yet attempted.

APPENDIX A

Geomagnetic Micropulsation Survey Form

GEOMAGNETIC MICROPULSATION SURVEY

I. Signal Components Normally Recorded:
(Use code below)

Code	
H_t	Total Magnetic
H_x	North Magnetic
H_y	East Magnetic
H_z	Vertical Magnetic
E_x	North Electric
E_y	East Electric
E_z	Vertical Electric
Other	Please specify

Signal Component	Bandwidths	Basic Instrument (Magnetometer, coils, etc.)	Normal Full Scale Sensitivity	Approx. % of time recording

II. Recording Sites:

Site	Signals Recorded	Status - past, present, future

III. Recording Equipment:

(Please describe briefly the type of recording equipment available including normal chart or tape speeds)

IV. Primary Interest or Specialization:

(Briefly indicate any special interest in the field of micropulsations, i.e., magnetotellurics, pearls, Schumann resonances, etc.)

V. Timing:

(Please describe basic timing device with an estimate of timing accuracy)

VI. Computing and Data Processing Facilities:

(Please describe briefly, including data processing facilities)

VII. Background Noise Level:

(Please describe any unusual noise problems at measuring sites)

VIII. Please indicate the extent you would be willing to cooperate in a joint measurement program at selected times.

IX. To what extent would you be able or willing to make available copies of selected data to others in a joint measurement program?

X. Equipment

(Please reference reports or publications which describe your equipment. If you have a brief equipment write-up, please include a copy.)

XI. Comments and Suggestions:

APPENDIX B

Research Group:

Ionospheric Physics Lab.
GRD - AFCRL
Bedford, Mass.

Reported by:

Elwood Maple

Special Interests:

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Strawberry Hill, Mass.	H	Coils	0.005-4 cps	Variable	±1 sec. or better	Continuous for selected intervals of several days or more each - since June 1962.
	H_x	"	"	"		
	H_y	"	"	"		
	H_z	"	"	Reserve-low sensitivity channels	"	
	H_x	"	"		"	"
	H_y	"	"		"	"
	H_x	Coil	1-50 cps	variable	"	"
Pt. Barrow, Alaska*						To start operation in 1963.

Notes and References:

* Equipment similar to Strawberry Hill to be furnished by AFCRL. Station to be operated by Dr. V. P. Hessler, Univ. of Alaska.
Recording on 7-channel, 1/2 in. tape, 0.1 or 0.05 ips. Also visual playback.

Research Group:

Geophysical Institute[1]
University of Alaska
College, Alaska

Reported By:

V. P. Hessler

Special Interests:

Broad coverage of high latitude earth current and micropulsation phenomenon, conjugate points, etc.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
College	E_x E_y	Earth probes-potentiometer-EA	dc-0.2 cps	1000 mv/km	6"/hr.*	100% since Oct. 1956
Barrow	E_x	Earth probes-potentiometer-EA	dc-0.2 cps	500 mv/km	6"/hr.*	
Conjugate Point-Alaska-Canada New Zealand, etc.	E_x E_y	Earth probes-potentiometer-EA	dc-0.2 cps dc-0.2 cps		6"/hr.*	See Final Report, Geophysical Institute AF 19(604)-3075
College	E_x	Earth probes-potentiometer-EA cycle counter	dc-1 cps	5 mv/km		100% since 1958

Notes and References:

[1] Continued on next page

* Chart speeds

Numerous reports of Geophysical Institute under Contract AF 19(604)3075.

Research Group:

Geophysical Institute
University of Alaska
College, Alaska
(continued)

Reported by:

V. P. Hessler

Special Interests:

(Listed on preceeding page)

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
College	E_x	Earth probes-potentiometer-EA micropulsation recorder	.05-.33 cps	400 mv/km	3"/hr.*	100% since Nov. 1962
College	E_x	Earth probes-potentiometer-EA micropulsation recorder and special trace on loop of chart paper	.1-1 cps	125 mc/km	3/4" * min	100% since Nov. 1961
	E_x		5-20 cps		30" * min	Under development
College	H_t	Rb. vapor magnetometer	variable	variable		Under development
	H_t	Helium vapor magnetometer				
Barrow	H_x H_y H_z	Coil systems and tape recording	.01-3 cps	2 channels on each 80 db range		100% will go into operation about March 1, 1963

Notes and References:

* Chart speeds

Research Group:

University of Alberta
Edmonton, Alberta, Canada

Reported by:

K. Vozoff

Special Interests:

Magnetotellurics and pulsation structure

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Leduc, Alberta, Canada	H_x	Iron Core Coils	2 millicps-	0.01 - 10γ	± 50 milli-sec	1%
	H_y		" 10 cps	"		
	H_z		"	"		
	• E_x	Copper rod electrode	2 millicps-	1 mv/km		
	E_y		" 8 cps	"		

Notes and References:

Research Group:

Institute of Earth Sciences
The University of British Columbia
Vancouver 8, Canada

Reported by:

J. A. Jacobs

Special Interests:

Micropulsation in the frequency range 0.2 - 10 cps - (pearls).

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Westham, island approx. 20 miles south of Vancouver	H_x	Iron core coils	0.01 - 5 cps	5 γ	1 sec	
	H^x		and 0.3 - 3 cps	.5 γ		H_x, H_y 80%
	H^y		"			H_z 20%
	H_z					
	H_x		0.01 - 5 cps	5 γ		At present 0%
	H^x		"	5 γ		
	H^y		"	5 γ		
	H_z					

Notes and References:

1. English, W. N., D. J. Evans, J. E. Lokken, J. A. Shand and C. S. Wright, Equipment for observation of the natural electromagnetic background in the frequency range 0.01-30 cps., Pacific Naval Laboratory reprint 61-3.
2. Shand, J. A., Proceedings of the meeting to discuss the cooperative low frequency electromagnetic measurement program of 1960, Pacific Naval Laboratory Note 60-42. Appendices C and D.

Research Group:

Department of Mineral Technology
University of California
Berkeley, California

Reported by:

S. H. Ward

Special Interests:

Tellurics - Structural studies
Dynamics of the Magnetosphere

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Briones Valley, California	H_t	R_b magnetometer	.0001-1 cps	2γ	±1 sec	25%
	H_{hor}	"	"	"		"
Sacramento, California	H_t	R_b magnetometer	0.001-1 cps	2γ		25%
	H_{hor}	"	"	"		"
	E_x		"	10 mv		"
	E_y		"	"		"

Notes and References:

Report in Process

Research Group:

University of Canterbury
P. O. B. 1471
Christchurch, New Zealand

Reported by:

C. Ellyett

Special Interests:

Annual variation of micropulsations with frequencies below 0.5 cps. Frequency drifts in the range 0.5 - 2 cps.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Department field station at Rolleston 15 mi. from Christchurch 172°24'20" E- 43°37'10" S	H_z H_z	ground loop	0.01-0.5 cps 1.3-1.7 cps	3γ at 0.05 cps 0.004γ	.1 sec	Continuous Set experiments

Notes and References:

Research Group:

Research Department
General Dynamics/Electronics
1400 N. Goodman Street
Rochester, N. Y.

Reported by:

Raymond A. Santirocco

Special Interests:

H_x, H_y, H_z at sea from 0.01-1 cps

Understanding signal sources and propagation phenomena.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Hathaway Hill, Penfield, N. Y.	H_x H_y H_z	Mumetal coils	.001-3 cps	2×10^{-2} γ/sec " "	Slow speed ± 10 - 15 sec Tape records ±(1 - 10) milli-sec	3%
Beneway Farm Ontario, N. Y.	H_x	Aircore loop	20-15,000 cps			

Notes and References:

A report will be issued shortly.

Research Group:

HRB-Singer, Inc.
Research Department
State College, Pa.

Reported by:

C. F. Sechrist, Jr.

Special Interests:

Correlation of geomagnetic micropulsations with VLF phase perturbations during periods of high micropulsation activity and magnetic storms. Spectrograms of geomagnetic and VLF phase fluctuation.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
State College, Pennsylvania 49°49' N 77°53' W geographic coordinates	H_x	Iron core coil	0.001-5 cps	100 γ at 0.001 cps 1 γ at 5 cps 70 γ at 5 cps	fraction of 1 sec	100%

Notes and References:

Report in process

Research Group:

High Altitude Observatory
Boulder, Colorado

Reported by:

S. Matsushita

Special Interests:

Micropulsations associated with known geomagnetic phenomena, such as SC, SI, bay, flare, P_c and so on.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
High Altitude Observatory Radio Astronomy Laboratory 3 miles north of Boulder.	H_t	R_b Vapor magnetometer	to 1 cps	6.6 γ per 100 divisions approx. 0.060 γ	synchronance clock driven from power line, checked once every 24 hours with WWV	100% since Jan. 1962

Notes and References:

Noise level "no problem."

Research Group:

Hughes Aircraft Co.
Communications Division
Los Angeles 9, Calif.

Reported by:

S. W. Lichtman

Special Interests:

Magnetotellurics directed towards propagation, detection and communication phenomena.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Culver City	E_x E_y	lead electrodes	0-100 kc "	0.7-40 mv/km "	.01 sec	Capable of 100%

Notes and References:

A report is available.

Research Group:

Jersey Production Research Co.
Tulsa, Oklahoma

Reported by:

F. G. Boucher

Special Interests:

Relationship between magnetotellurics and other phenomena

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Leonard, Okla.	H_t	Metastable Helium Mag.	0.01 - 1 cps	1 γ	*	100%
	H_x	Magnetometer	Long period	2.7 γ/mm	2 sec*	100%
	H_y					
	H_z					
	E_x	Potential spreads		x & y 20 mv		100%
	E_y	x and y 1000'	dc - 1 cps	z 10 mv		100%
	E_z	z 0-1200'-2400'				
	Variations electron density in ionosphere	Riometer				

Notes and References:

* Accuracy of picking events based on chart speeds used.

Research Group:

Lamont Geological Observatory
Torrey Cliff
Palisades, New York

Reported by:

J. Heirtzler

Special Interests:

1 - 1000 sec periods and their spectral variations.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Lebanon State Forest, N.J.	H_t	R_b Magnetometer	0 - 1 cps	2γ or 6γ	±0.1 sec/day ±0.01 sec/hr	greater than 50%
Ocean bottom	H_t	Proton precession magnetometer	0 - 0.05 cps	300γ		100%
Lebanon State Forest, N.J.	H_x H_y	Cored coils				future

Notes and References:

Research Group:

Lockheed Aircraft
Physical Sciences Lab.
Palo Alto, Cal.

Reported by:

Lee R. Tepley

Special Interests:

Pearls

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Palo Alto, Cal.	H_t	Proton Mag.	0-1/60 cps	100 γ		100% since
	H_x	Air Core Loop	0.3-7 cps	0.0003 γ*	0.1 sec	Feb 61 through 63.
	E_z	Vertical Antenna	5-50 cps	50 μv/m*		
Hawaii,	H_x	Iron Core Loop	0.3 - 7 cps	0.001 γ*		May-Aug, 62, 100%
Tonga-Tapu	E_x	Earth Current	0.3 - 50 cps	20 μv/km*	0.1 sec	Sept 62 - Jan 63
(Tonga Islands)	E_y	" "	"	"		100%
Canton Island	H_x	Iron Core Loop	0.3 - 7 cps	0.001 γ*	0.1 sec	Sept 63 to present
	H_y	" " "	0.3 - 7 cps	0.001 γ*		100%

Notes and References:

* Instrument Noise Levels

"Structure and Attenuation of Hydromagnetic Emissions," Vol. I and II, Lee R. Tepley and R. C. Wentworth, Lockheed Missiles and Space Co., Scientific Report No. 1, 6 April 1962.

Research Group:

Massachusetts Institute of Technology
Cambridge, Massachusetts

Reported by:

T. Cantwell and
T. Madden

Special Interests:

Magnetotellurics, pearls, Schumann resonances, and other interesting geomagnetic phenomena.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Mobile sites in Mass., N. H., Maine	E_x E_y H_y H_x	Horizontal grounded antenna μ metal coils	0.005-2 cps and 0.05-50 cps "	5 mγ/cps		Mobile station only at present time.
Fixed Site to be set up 20 miles west of Boston	E_x E_y					

Notes and References:

T. Cantwell PhD Thesis and letter in J. G. R.

Research Group:

National Aeronautical Establishment
Ottawa, Canada

Reported by:

Murray Strome

Special Interests:

Airborne magnetometers - Noise power of magnetic background 0.05 - 1.0 cps

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
1) Peat bog	H_t	Coil	0.05-0.5 cps	0.7 γ	±0.2 sec	100%
2) Uplands airport[1]	H_t	Magnetometer	0-1.0 cps	2.0 γ	"	As planned
3) Airborne	H_t	"	"	"	" (.02 sec with special precautions)	"

Notes and References:

[1] 0.2 γ background reduces usefulness.

Research Group:

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California

Reported by:

Darrell D. McKibbin

Special Interests:

Earth-Solar Magnetic Fields

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
	H_t	Stationary Search Coils Fluxgate H_e-Magnetometer	0-50 cps	1-100 γ		

Notes and References:

Research Group:
Naval Ordnance Lab.
Silver Spring, Md.

Reported by:
C. R. Larkin

Special Interests:
Background at sea

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
White Oak Silver Spring, Maryland and sea bottom	H_t	Helium Mag.	0.01-10 cps	2, 6.7, 20γ	Not specified Tuning fork and xtal reference	No definite schedule. Some measurements on sea bottom
	H_t	Rb. Mag.				
	H_x	Coils	to 1 cps			
	H_y	"	"			
	H_z	"	"			

Notes and References:

Naval Ordnance Laboratory Technical Report 61-7

Research Group:

Advanced Systems Analysis
Space and Information Systems Div.
North American Aviation, Inc.
Downey, California

Reported By:

R. A. Fowler

Special Interests:

Magneto-tellurics from nuclear blast and missile firing as well as from solar terrestrial interaction.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Santa Susana Mountains Chatsworth, California	E_x E_y	1000 ft. apart ground probes	0-40 cps 30 cps-30 Kc 100 cps-1 Kc 200 cps-2.5 Kc	.4-500 micro $\frac{\text{volts}}{\text{meter}}$	1 millsec.	Only during nuclear tests.
	H_x H_y H_z	air core loop	0-40 cps 30 cps-30 Kc 100 cps-1 Kc 200 cps-2.5 Kc	0.001 γ 0.001 γ 0.001 γ		

Notes and References:

Magneto-Teleric Data Collection and Data Handling Capabilities
North American Aviation Inc.

Research Group:

Pacific Naval Laboratory
Victoria, B. C.

Reported by:

J. A. Shand

Special Interests:

Relationship with ionosphere, conjugate effects, directional effects of micropulsation and ELF, latitude effects.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Westham Island, B. C.[1] (near Vancouver)	H H^x H^y_z	Coil " "	0.003 - 3 cps " "	Noise level <0.01 γ peak to peak at 1 cps	Radio signals on tape Accuracy not specified	Experimental
St. Hilaire, P. Q.[2] (near Montreal)	"	"	" Also 2-40 cps	Depends on station	"	Experimental Specified schedules
Byrd Station,[3] Antarctica Great Whale River, P. Q.	H H^x H^y_z H_t	Coil " " Rb. Mag.	Approx. 0.1 cps near selected frequencies 0-2 cps	Noise level <0.0001 γ 80 γ, 200 γ	" "	6"/hr most of time - higher speed on certain schedules. Tape used on schedule. Some operations only.
Ralston, Alberta						Future

Notes and References:

[1] Operated by University of British Columbia
[2] Operated by McGill University
[3] Operated by Stanford University
[4] Type of measurements at each location appear to be flexible to a certain extent.

Research Group:

University of Puerto Rico
Mayaguez, P. R.

Reported by:

Prof. Braulio Dueno

Special Interests:

Relationship between geomagnetic micropulsations and ionosphere, radio-star ionospheric drift experiment.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Mayaguez, P. R.	H_t	Rb. Vapor Magnetometer	3 kc	20γ	6 in/hr* 6 in/min*	100%

Notes and References:

*Chart speeds

Research Group:

Dept. of Electrical Engineering
University of Rhode Island
Kingston, R. I.

Reported by:

C. Polk

Special Interests:

Schumann resonances and related phenomena.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Kingston, R.I. lat. 41°29'45" Long. 71°31'37"	H_x H_y	Iron Core Coils*	50-20 cps	2×10^{-5} amp/m	Ordinary mechanical clock $\pm$1 sec Checked by NBA	Sample one minute every ten minutes 24 hrs/day

Notes and References:

* Extremely low frequency reception at Kingston, Rhode Island
C. Polk and F. Fitchen, Scientific Report No. 1

Journal of Research of the NBS, Vol. 66 D, No. 3, May-June 1962, p. 313-318

Research Group:

Apparatus Division
Texas Instruments, Inc.
6000 Lemmon Avenue
Dallas, Texas

Reported by:

Arthur W. Green, Jr.

Special Interests:

Magnetotelluric micropulsation power spectra and frequency of occurrence data from 0.01 to 20 cps.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Grand Prairie and Grapevine, Tex.	H_t	Metastable helium magnetometer	0.01-2.0 cps	0.25, 0.5 1, 5γ		
	E_x		0.01-2.0 cps	0.8 mv/km	0.1 sec	10%
	E_y		"	and 8 mv/km "		
Only Grand Prairie	H_x	Permeable core probes	1 - 2 cps			future
"	H_y	"	"			

Notes and References:

Green, A. W., Jr. and List, B. H., "The Theory Measurement and Applications of Very Low Frequency Magnetotelluric Variations," Proc. I.R.E., Nov. 1962.

Research Group:

Electrical Engineering Research Laboratory
The University of Texas
Austin, Texas

Reported by:

H. W. Smith
F. X. Bostick

Special Interests:

Magnetotellurics, coherence of component signals over large distances.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Austin, Texas Fixed station	H_x	Air Core Coils	0.002-2 cps	1 γ	.01 sec	100%
	H_y					
	H_z					
	E_x	Ground probes	0.005-2 cps	1 mv/km		
	E_y					
Mobile station	H_x	Iron Core Coils	0.002-10 cps	1 γ	.01 sec	Variable at different sites
	H_y					
	H_z					
	E_x	Ground Probes	0.005-10 cps	250 μv/km		
	E_y					
Past Mobile Sites						
Grand Bahama Is.	Oct. 1961 - Jan. 1962					
Puerto Rico	June - Oct. 1962					

Notes and References:

EERL Report Nos. 111, 112, 113, 115, 116, 118, 119, 120, 123, 126, 127, 128

J. G. R. March 1961

Research Group:

U. S. Coast and Geodetic Survey
Washington, D. C.

Reported by:

L. R. Alldredge

Special Interests:

General interest in all phases including short period fluctuations.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Fredericksburg, Va. Tucson, Ariz. Barrow, Alaska College, Alaska Sitka, Alaska Honolulu Guam Byrd Sta., Antarc. Eights Sta., "	H_h # H_d H_z	Magnetograph using suspended or balanced permanent magnets	dc - 0.2 cps dc - 0.2 cps dc - 0.1 cps	2 to 5 gammas/mm of ordinate	*	100% at all except Eights Station, Antarctic which is currently being installed.

Notes and References:

\# Conventional geomagnetic terminology

* Sufficient and consistent with chart speeds

cont'd on next page

Research Group:

U. S. Geological Survey
Theoretical Geophysics Branch
Denver, Colorado

Reported by:

George V. Keller

Special Interests:

Magnetotelluric Field - resistivity determination

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Bergen Park Observatory (35 miles west of Denver, Colo.	E_x E_y H_t^y H_t H_x H_y	Earth probes " " Helium-Vap. Mag. Air Core Coils[1] " " "	Not Specified	Not Specified	Crystal-controlled electronic clock - WWV to 10 m sec at best	Schedule not given. Recording on May tape at 0.3 ips and 4 channel visual monitor at chart speed 1 cm/min
Hawaiian Volcano Obs. (30 miles S. of Hilo, Hawaii)	E_x E_y H_z	Earth probes " " Air core coil[2]	Not Specified	Not Specified	Mechanical chronometer ref - WWV once daily	Schedule not given. Normal recording - 4-channel charts at 1.5 cm/min. Speeds to 600 cm/min.
Mobile Magneto-telluric Obs.	E_x E_y H_t^y H_t H_x H_z^y	Earth probes " " Rb. - Vap. Mag[3] " " " " " " Air core coil[4]	Not Specified	Not Specified	xtal-cont. WWV-Rec.	Schedule not given. Recording on mag tape at 0.3 ips and 4-channel recorder - 1.5 cm/min to 600 cm/min chart speeds

Notes and References:

1. Effective area - 64,000 sq. meters
2. 25×10^6 sq. meter coil to be added before end of 1962
3. Magnetometer modified to record total field or a component or components sequentially
4. Effective Area - 52,000 sq. meters

Research Group: U. S. Geological Survey (cont'd)

Reported by: George V. Keller

Special Interests:

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Mobile Earth Current Systems (3 systems)	E_x E^x $H^{y}5$ $H^{x}5$ $H^{y}6$ H_z	Earth probes " " Air core coils " " " " " "	Not specified	Not specified	xtal-cont. WWV-Rec.	Schedule not given. Recording on 4-channel recorder with speeds 1.5 cm/min to 600 cm/min Also 7-channel recorder with speeds 3.6 cm/min to 3600 cm/min.

Notes and References:

5. Effective area - 64,000 sq. meters
6. Effective area - 52,000 sq. meters

Research Group:

U. S. Naval Air Development Center
Johnsville, Pa.

Reported by:

D. P. Miles

Special Interests:

Observation of magnetic storms, micropulsations and related earth current effects relative to magnetic anomaly detection equipment.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
U. S. Naval Air Dev. Cent. Johnsville, Pa. Lat. 40°12' N. Long. 75°04' W.	H_t	Proton Prec. Mag.	1 reading/min	70 γ	at 6"/hr ±15 sec. - at 2"/min ±1 sec.	75% past, present, future
	H_t	Rb. Vap. Mag.	0 - 1/4 cps	6.7 γ*		75% "
	H_t	Rb. Vap. Mag.	0.07 - 0.7 cps			
	H_v	Coils			Future	
	E_x				"	
	E_y				"	

Notes and References:

* 2 γ full scale during special events
Recording on paper charts with mag. tape to be installed.
U. S. Naval Air Development Center Reports No. NADC-AW-6226 and 6240.

Research Group:

U. S. Naval Oceanographic Office
Marine Sciences Department
Washington 25, D. C.

Reported by:

R. H. Randall, Jr.

Special Interests:

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Wallops Is., Virginia						Not yet operational

Notes and References:

Research Group:

Instrument Division
Varian Associates
611 Hansen Way
Palo Alto, Calif.

Reported by:

Breiner

Special Interests:

Providing magnetometers to record at all frequencies. Gradiometer configurations, cancelling out micropulsation activity over distance of a few feet to a few miles.

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Site 501 Stanford University Varian Associates Palo Alto, Cal	H_t	R_b Vapor magnetometer	0.001-3 cps	20γ	±1 sec	80%

Notes and References:

Varian Associates Rubidium Vapor Station Magnetometer
X-4936 Data Sheet

Research Group:

Victoria Magnetic Observatory
Royal Oak, B.C., Canada

Reported By:

B. Caner

Special Interests:

Accurate timing of magnetohydrodynamic phenomena.[1]

Statistical processing of geomagnetic data obtained under rigidly controlled conditions (i.e. stable and well defined sensitivity, wide-band linear frequency response etc.)

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % time
Victoria Magnetic Observatory Geographic Coordinates 48°31'N - 123°35'W	Magnetic Field Declination Horizontal H_z	Three component fluxgate.[2] (Saturable core) Modified for increased sensitivity	0.1-1 cps	10γ, 20γ 10γ, 20γ 10γ, 20γ	Slow recording ±5 sec on hour mark Fast recording ±0.1 - ±0.2 sec.	Declination-intermittent 100% by 1963 Horizontal and H_z not operational until 1963

Notes and References:

*Reference

1. Caner and Whitham, Can. J. Physics, 1962, Vol. 40 No. 12
2. Serson, Can. J. Physics, 1957, 35, 1387.

Research Group:

Department of Geophysics
Weston Observatory
Weston 93, Mass.

Reported by:

Daniel Linehan, S. J.

Special Interests:

Absolute calibration of magnetic instruments

Recording Site	Signal Component	Basic Instrument	Bandwidth	Full Scale Sensitivity	Timing Accuracy	Recording Status and % Time
Weston Observatory, Weston	H_t	R_b Vapor magnetometer	0 - 0.2 cps	20 γ		100%
	H_z	Proton precession magnetometer	0 - 0.02 cps	2000 γ		
	H_H	"	"	2000 γ		
	Declination	"	"	2000 γ		
	E_x		0 - 1 cps	100 mv/500 ft		
	E_y		"	200 mv/2K ft		100% experimental
	E_y		"	100 mv/500 ft		

Notes and References:

Transactions of AGU, Sept. 1961.
Weston Magnetic Facility, R. O. Hutchinson, J. Pomeroy, S. J.

Contract Nonr 375(14)

DISTRIBUTION LIST

Addressee	Attention	No. of copies
ASTIA Arlington Hall Station Arlington 12, Virginia	TIP-Dr	10
Director of Defense Research & Development The Pentagon Washington 25, D. C.	Technical Library Room 3C-128	1
Office of the Chief Signal Officer Department of the Army Washington 25, D. C.	SIGFO-64	1
Engineering & Technical Division Office of the Chief Signal Officer Department of the Army Washington 25, D. C.	SIGET	1
Director of Research U. S. Army Signal Research & Development Laboratories Fort Monmouth, New Jersey		3
Commanding Officer U. S. Army Signal Research & Development Laboratories Fort Monmouth, New Jersey	N. Abbott	1
Administrative Engineer Signal Corps Engineering Laboratory Fort Monmouth, New Jersey		1
Chief of Naval Research Department of the Navy Washington 25, D. C.	Code 427 Code 416	2 1
Director U. S. Naval Research Laboratory Washington 25, D. C.	Code 2000 Code 2027 Code 1360	6 2 1
Chief, Bureau of Ships Department of the U. S. Navy Washington 25, D. C.	Code 337 Code 686	2 2
Chief, Bureau of Aeronautics Department of the U. S. Navy Washington 25, D. C.,	EL 50 EL 90	1 1
Department of the Navy ONR, Boston Branch Office 495 Summer St. Boston 10, Massachusetts		1

Bureau of Naval Weapons Department of the U. S. Navy Washington 25, D. C.	RRE-3	1
Chief of Naval Operations Frequency Allocation Sect. OP-941Q Room 5E777, The Pentagon Building Washington 25, D. C.		1
Chief of Naval Operations Department of the U. S. Navy Washington 25, D. C.	Op 413	1
Director, ONR Branch Office 346 Broadway New York 13, N. Y.		1
Director, ONR Branch Office The John Crerar Library Building 10th floor 86 E. Randolph St. Chicago 1, Illinois		1
Chief Scientist ONR Branch Office 1030 Green Street (East) Pasadena 1, California		1
Officer in Charge, ONR Navy No. 100 - Fleet Post Office New York, N. Y.		1
Commanding Officer U. S. Naval Underwater Sound Laboratory New London, Connecticut		1
Commanding Officer Naval Air Development Center Johnsville, Pennsylvania	AAEL	1
Director Naval Ordnance Laboratory White Oak, Maryland		1
Commander U. S. Naval Ordnance Test Station China Lake, California	Technical Library Code 753	1
Librarian, U. S. Naval Postgraduate School Monterey, California		1
U. S. Naval Electronics Laboratory San Diego 52, California	Library	1

Alderman Library University of Virginia Charlottesville, Virginia	John C. Wylie	1
Commanding General Hq., USAF Washington 25, D. C.	AC-AS/4:AFDRE	1
Aeronautical Systems Division Deputy for Technology-Avionics Div. Electromagnetic Warfare & Comm-ications Electromagnetic Environment Branch Propagation Section Wright-Patterson AFB, Ohio	Paul W. Springer ASRNCF-2	1
AF Cambridge Research Laboratories Electronics Research Directorate Office of Aerospace Research L. G. Hanscom Field Bedford, Massachusetts	CRRK CRRI CRRD CRRS	1 1 1 1
AF Cambridge Research Laboratories Geophysics Research Directorate Office of Aerospace Research L. G. Hanscom Field Bedford, Massachusetts		1
Commander AF Office of Scientific Research Washington, D. C.	Dr. Wm. J. Otting, Jr.	1
U. S. Weather Bureau Department of Commerce Washington, D. C.	Director Radar Engineering	1
Boulder Laboratories National Bureau of Standards Boulder, Colorado	Library W. H. Campbell Ionospheric Res. & Propagation Div.	1 1
Office of Technical Services U. S. Department of Commerce Washington 25, D. C.		1
ITT Laboratories 3700 E. Pontiac Street Fort Wayne, Indiana	Mrs. Ann Bley	1
Maurice W. Long Engineering Experiment Station Georgia Institute of Technology Atlanta 13, Georgia		1

Department of EE University of Michigan Ann Arbor, Michigan	Dr. S. S. Atwood	1
Research Laboratory of Electronics M. I. T. Cambridge, Massachusetts	H. Zimmerman	1
Federal Communications Commission Room 2209, New P. O. Bldg. Washington 25, D. C.	Asst. Chief Engineer in charge of Technical Research Division	1
Stanford Electronics Laboratories Stanford University Stanford, California	Applied Electronics Lab Document Library	1
Library, ERL 427 Corey Hall, Univ. of California Berkeley 4, California	Miss L. Khouri	1
Documents Library R-3446 General Electric Company Missile and Space Vehicle Dept. 3198 Chestnut Street Philadelphia 4, Pa.	Lawrence I. Chasen Mgr., Library	1
Bell Telephone Company P. O. Box 107 Red Bank, New Jersey	Dr. R. Kompfner	1
Dr. William A. Miller Senior Staff Scientist Electronics Systems Division Fairchild Stratas Corp. Straight Path Wyandanch, N. Y.		1
Electrical Engineering Res. Labs. University of Illinois Urbana, Illinois	P. D. Coleman	1
RCA Laboratories Princeton, New Jersey	Miss Fern Cloak	1
Technical Reports Collection Gordon McKay Library Harvard University Div. of Eng'g. and Appl. Physics Pierce Hall, Oxford Street Cambridge 38, Massachusetts	Mrs. Elizabeth Farkas	1
School of Electrical Engineering Cornell University Ithaca, New York	Dr. W. E. Gordon	1

Commandant (EEE) U. S. Coast Guard (Sta 5-5) 1300 E Street, N. W. Washington 25, D. C.		1
M. I. T., Lincoln Laboratory Box 73 Lexington 73, Massachusetts	Dr. James H. Chisholm	1
Dept. of Electrical Engineering California Institute of Technology Pasadena, California	Dr. C. H. Papas	1
Applied Physics Laboratory The Johns Hopkins University 8621 Georgia Avenue Silver Spring, Maryland	Geo. L. Seielstad	2
New York University Institute of Mathematical Sciences 25 Waverly Place New York 3, N. Y.	Prof. Morris Kline	1
Program Director, Eng'g. Sciences National Science Foundation Washington 25, D. C.		1
Antenna Research Laboratory Ohio State University Columbus 10, Ohio	Dr. Thomas Tice	1
Tektronix, Inc. P. O. Box 500 Beaverton, Oregon	Library	1
Smyth Research Associates 3555 Aero Court San Diego 11, California	Electronics Branch	1
Cornell Aeronautical Laboratory, Inc. 4455 Genessee Street Buffalo 21, New York	John P. Desmond, Librarian	1
New York University College of Engineering Dept. of Meteorology & Oceanography University Heights New York 53, N. Y.	Prof. W. J. Pierson	1
Dr. Nicholas George 333 Spalding Building California Institute of Technology Pasadena, California		1

Texas A & M College College Station, Texas	Dr. Vance Moyer, Radar Met. Section	3
Sylvania Electric Products, Inc. P. O. Box 205 Mountain View, California	Miss Katherine Johnson Electronics Defense Lab.	1
Radio Research Laboratories Ministry of Post & Telecommunications Kokubunji Post Office Tokyo, Japan VIA: U. S. Naval Attache for Air Tokyo, Japan	Planning Section	1
Harvard Observatory 60 Garden Street Cambridge 38, Massachusetts	A. E. Lilley Dept. of Radio Astronomy	1
University of Arizona Tucson, Arizona	Mr. George Savage Inst. of Atmos. Physics	1
Technical Research Group, Inc. 2 Aerial Way Syosset, New York	Jerome R. Lurye	1
Loral Electronics Corporation 835 Bronx River Avenue New York 72, N. Y.	W. Honig	1
National Bureau of Standards P. O. Box 299 Boulder, Colorado	Mr. M. C. Thompson	1
Research Laboratory of Electronics Chalmers Institute of Technology Gothenburg, Sweden	Christina Walsh	1
Advanced Research Projects Agency Room 3D 170, The Pentagon Washington 25, D. C.	Lt. Cmdr. D. E. Chandler	1
Alan H. Barrett, Assoc. Prof. Room 26-49 M. I. T. Cambridge 39, Massachusetts		1
Hughes Aircraft Company Communications Division Box 90902 Los Angeles, California		1

Dr. C. I. Beard Boeing Scientific Research Labs. P. O. Box 3981 Seattle 24, Washington		1
Mr. Charles R. Burrows Senior Scientist Radio Eng'g. Labs., Inc. 4925th Street, Elmo Ave. Bethesda 14, Maryland		1
University of Chicago Laboratories for Applied Sciences Museum of Science & Industry Chicago 37, Illinois		1
Instituto Geofisico del Peru Apartado 3747 Lima, Peru	Dr. Robert Cohen	1
Jet Propulsion Laboratory California Institute of Technology 4800 Oak Grove Drive Pasadena, California	I. E. Newlan Technical Reports Section	1
Manila Observatory Ateneo De Manila University P. O. Box 1231 Manila, P. I.		1
Geophysical and Polar Research Center University of Wisconsin 6021 South Highland Road The Highlands Madison 5, Wisconsin	Mr. Forrest L. Dowling	1
Director U. S. Army Engineer Research and Development Laboratories Fort Belvoir, Virginia	Technical Documents Center	1
U.S. Army Materiel Command Harry Diamond Laboratories Room 211, Building 92 Washington 25, D. C.	Mrs. A. Porter	1